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EFFECT OF FIBRE VOLUME FRACTION ON DYNAMIC PROPERTIES OF GLASS FIBRE REINFORCED POLYMER (GFRP) COMPOSITE MATERIAL

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Abstract: Comprising of two or more different constituent materials which have different physical or chemical properties, composites respond differently under various dynamic impacts. The present research work is aimed at the development of Composites of epoxy resin with varying volume fraction of unidirectional continuous glass fibres for calculating their dynamic mechanical properties. Experiments were conducted to calculate storage modulus, loss modulus ,loss factor as a function of temp and glass transition temperature for different samples by using three point bending mode on Triton Dynamic Mechanical analyzer.

Keywords: Dynamic Mechanical Analysis (DMA), Glass Fiber Reinforced Polymer (GFRP)

1. INTRODUCTION

To form a composite, two or more different constituent materials which have different physical or chemical properties are used and they do not merge in the finishing structure i.e. the individual constituents retain their properties. The existence of composite materials dates back, before its significance was acknowledged and its whereabouts known. Owing to its amazing mechanical properties composite materials have touched many aspects of our lives in advanced society. Composites have influenced textile industry, automobile parts, and machine tools, seismic resistant and high strength buildings.

Dynamic Mechanical Analysis is a technique of applying the oscillating force to the experimental sample for determines the mechanical property which varies with the applied force. It determine the visco-elastic character of the material. This Technique is based on five factors: Temperature, frequency, time, force and strain of the above can change the dynamic characteristics of the material. The sample used should be of sufficient solid or viscous liquid form.

The properties determined like storage modulus, loss modulus, damping factor are calculated as a function of temperature when the sample is subjected to sinusoidal load at a particular temperature range and specified atmosphere. The experiments have been performed by using Triton dynamic mechanical thermo analyser Maninkandan [1] evaluated the addition of sisal fibre in composite through Dynamic mechanical thermal analysis. Weight of sisal fibre was varied and found that glass transition temperature was shifted towards the higher temperature with fiber loading and storage modulus E' decreases with increase of temperature. Alvarez [2] evaluated the effect on the Loss modulus, storage modulus and loss factor of unidirectional glass fiber composites by using two types of coatings of epoxy resin on the glass fibers and found that the modulus depend more on the L/H ratio than load ratio . Mallarino [3] examined the sizing effect in composite material. And concluded that sizing molecule dissolution into resin induces network plasticization. Goertzen [4] calculated the dynamic mechanical analysis of carbon/Epoxy composites used for pipe

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repair. DMA analysis concluded that glass transition temperature Tg is higher for post cured specimen at 95° C for 24 hrs. Huang [5] examined the dynamic mechanical analysis of saline water treated glass fiber/ unsaturated polyester composites by varying treating period of the samples. The damping or energy dissipation increases with dispersing time of specimen. Maadeed [6] examined the effect of chain structure on the various mechanical properties of Glass fiber and polyethylene composites. The polyethylenes are classified into high density polyethylene MDPE, ultra high molecular weight HDPE, Low density polyethylene (LDPE) and very low density polyethylene. The experimental result investigates that young's modulus increases in case of LDPE by a factor 5.5 but it is very less increase in case of MDPE, HDPE. Fauzani [7] studied the effect of processing temperature on the dynamic analysis and tensile strength characteristics of the kenaf fiber or high density polyethylene composite and showed that storage modulus is higher with a value of 16.15 GPa at a temperature of -130°C with a higher fiber fraction of 17.5 wt%.

In the present work focus has been laid to develop a composite of continuous glass fibre as reinforcement in epoxy and to study the effect on storage modulus, loss modus, loss factor and glass transition temperature of Glass fibre reinforced composite with varying temperature and frequency using DMA technique.

2. EXPERIMENTAL

2.1. Material

E-glass fiber (density: 2.6 g/cm3) of 140 mm length were used as filler material. LAPOX C-51 resin was used as structural matrix. It was selected as the matrix material due to its low viscosity (at 250 C) and density of 1.13-1.16g/cm3.The flash point of lapox C-51 is greater than 190°C. With lapox C-51 as a resin Hardener K-6 is employed. This hardener is fairly reactive and hence produces a strong exothermic reaction.

2.2. Sample Preparation

For manufacturing of glass fiber reinforced polymer composite, the required amount of lapox C-51 and hardener K-6 were taken and mixed together in the ratio of 75:25 by weight. The hardener and epoxy resin mixture was then stirred at a controlled rate so that bubble formation can be controlled which further prevents incomplete filling in the sample formation. Then this mixture is poured on the fibre aligned in unidirectional way in a mould of thickness 3mm for sample Preparation and mould is hot pressed for 6-8 hours with a force of 1.5 Ton per square inch. Four samples were prepared of size 50×10×2 by varying the volume fraction 11%, 37%, 53%, 80% respectively of fibre and one pure epoxy -hardener sample was prepared.

For characterizing the dynamic properties of glass fiber reinforced composite, various kind of testing were done on the composite samples. The tests performed on the samples prepared are DMA test for identification of damping properties and DMA test for identification of glass transition temperature using Triton Dynamic Mechanical analyzer at three point bending mode

3. RESULTS AND DISCUSSIONS

The effect of increase of temperature on storage modulus (E'), loss modulus (E") and loss factor (tan δ) of FRP samples at frequency 1 Hz is shown in Fig.1, Fig.2 and Fig.3 respectively and table 1.

FRP sample having VF: 80 % layers in it has highest storage modulus value of 59.8 Gpa, when compared to rest of the composites sample.

The Pure epoxy hardener composite has loss modulus 0.889 GPa peak at 34.4°C. This peak also referred as the glass transition temperature (Tg). The glass fibre content changes in FRP's result in shifting of the peak to higher temperature composite samples.

Table1
The comparison of storage modulus, loss modulus of different volume fractions at frequency 1Hz and 2Hz.

Samples	*Temp. (°C)*	*Storage modulus (GPa) (1Hz)*	*Storage modulus (Gpa) (2Hz)*	*Loss modulus (GPa) (1Hz)*	*Loss modulus (Gpa) (2Hz)*
Pure Epoxy Hardener sample	44 (°C)	1.766	2.718	0.237	0.741
VF: 11%	44 (°C)	6.492	8.81	1.13	1.574
VF: 37%	44(°C)	26.78	27.70	1.661	1.86
VF: 53%	44 (°C)	42.24	33.13	3.358	3.569
VF: 80%	44 (°C)	58.56	63.48	3.970	4.09

Pure Epoxy Hardener composite exhibit a higher tan δ peak value as compared to fibre reinforced composite samples. Among the fibre reinforced sample, VF: 11% reinforced composites showed a lowest tan δ peak values. Since the percentage change in tan δ of VF: 80 % with respect to Pure epoxy hardener composite is higher as compared to other FRP's compositions. In case of VF: 80% composite, the storage modulus is highest but on the contrary it also it also has the lesser value of tan δ as compared to VF: 53%.

The effect of increase of temperature on storage modulus, loss modulus and loss factor (tan δ) of FRP samples at frequency 2 Hz is shown in Fig.4, Fig.5 and Fig.6 respectively and table 1. It is observed that storage modulus of pure epoxy hardener sample at frequency 2 Hz are higher than that of Pure Epoxy hardener composites at a frequency of 1 Hz. It is observed that pure epoxy hardener have greater loss modulus at 44ºC under frequency of 2 Hz as compare to the testing under 1 Hz but it also enlisted that the loss modulus values of FRP's sample tested under the frequency of 2 Hz has

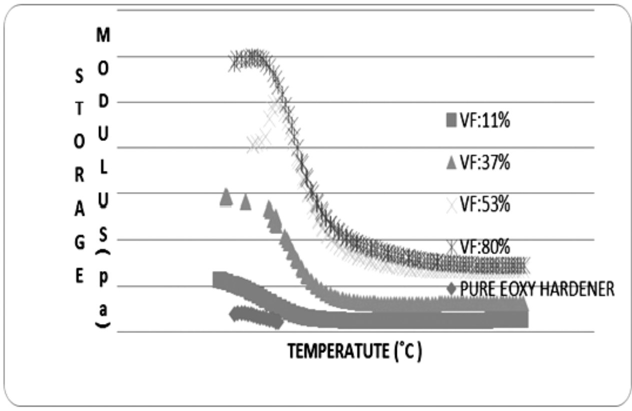

Figure 1: Variations in storage modulus vs. temp. due to change in Glass fibre content in FRP (Frequency = 1Hz)

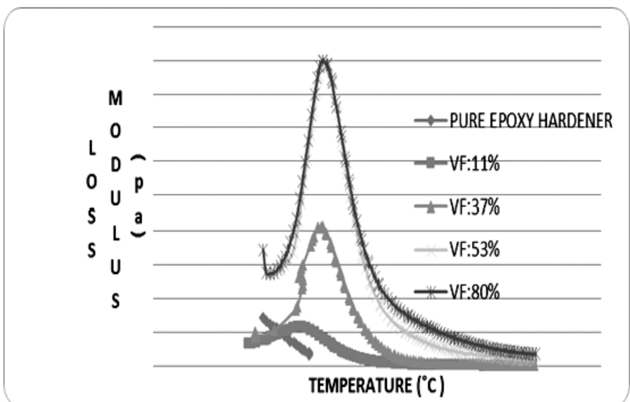

Figure 2: Variations in loss modulus vs. temp. due to change in Glass fibre content in FRP (Frequency = 1Hz).

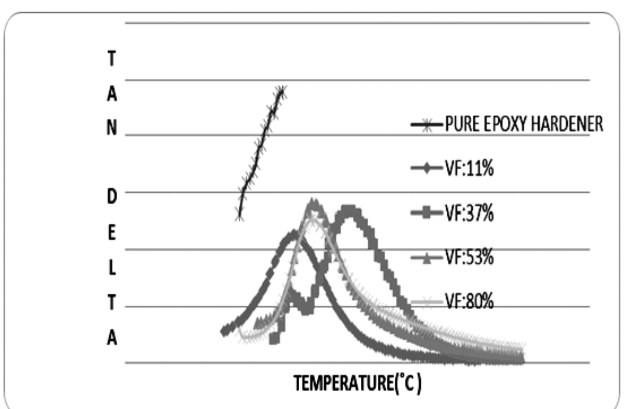

Figure 3: Variations in tan delta vs. temp. due to change in Glass fibre content in FRP(Frequency=1Hz).

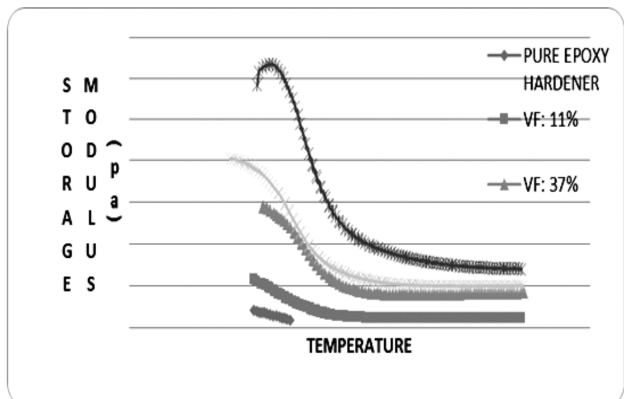

Figure 4: Variation in storage modulus vs temperature due to change in fibre percentage in FRP's (Frequency = 2Hz).

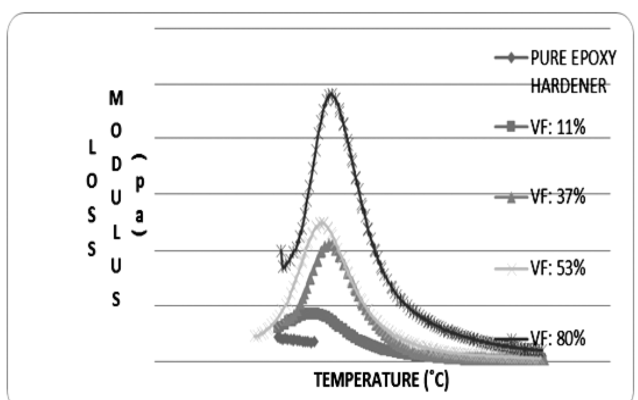

Figure 5: Variation in loss modulus vs temperature due to change in fibre percentage in FRP's (Frequency = 2Hz).

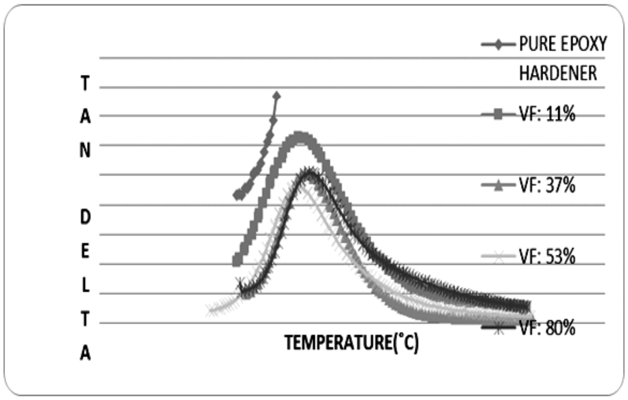

Figure 6: Variation in tan δ vs temperature due to change in fibre percentage in FRP's (Frequency=2Hz).

more values as compared to the tested under frequency of 1 Hz. Pure epoxy hardener composites exhibit a higher tan δ peak value as compared to GFRP composites. .Pure epoxy hardener composites exhibit a higher tan δ peak value as compared to GFRP composites. Higher tan δ peak value for pure epoxy hardener composite may be attributed to more energy dissipation by internal friction at the weaker interface between glass fibre and matrix. Among the glass fibre reinforced composites, (VF: 53%) composites showed a lowest tan δ peak values. Since the tan δ peak value is related to fiber matrix adhesion, lower tan δ peak value of VF: 53% corresponds to better adhesion and compatibility between glass fibers and resin than that of the other FRP's samples.

4. CONCLUSIONS

With the increase in the percentage of glass fibre content in the FRP composite samples, the strength of the sample increases as a result of which storage modulus increases but on the other side it weakens the bonding between the glass fibre and matrix material because of decreasing percentage of matrix material that increases the loss modulus under dynamic loading. Since the tan δ peak value is related to fibre matrix adhesion, low tan δ peak value of VF: 11% composite correspond to better adhesion and compatibility between glass fibre and epoxy resin matrix than that of other FRP samples.

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